

6. On the Relative Positions to their Constructors of the Chambered Shells of Cephalopods. By Prof. OWEN, C.B., F.R.S., F.Z.S., &c.

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(Plate LX.)

The relations of the chambered and siphonated shells to their constructors can now, owing to the extent to which they have been subject to extinction, only be fully elucidated by a study of species or varieties of two of the genera, *Nautilus* and *Spirula*.

The fossil shells of Cephalopods, as is well known, exhibit a progressive uncoiling from *Nautilus* to *Orthoceras* and from *Ammonites* to *Baculites*, with various modifications of the process; but that this had been carried out to a coiling in the reverse direction, required anatomical evidence for its demonstration.

The insight, however, gained into the organization of *Spirula peronii* at the date of the publication of the 'Zoology of the Voyage of the Samarang'<sup>1</sup>, added to that previously obtained on the organization of *Nautilus pompilius*<sup>2</sup>, led me to express a conviction of their shell-relations in the following terms:— "These shells (*Nautilus* and *Ammonites*) are revolutely spiral or coiled over the back of the animal, not involute like the *Spirula*"<sup>3</sup>. And, if the direction of the coils be determined by their relation to the back and belly of the framer of the shell, no other interpretation can be given of such relation as it is exhibited in *Spirula* (Plate LX. fig. 4) and *Nautilus* (ib. fig. 3) respectively.

It is, however, to the exposition and characters of the extraordinary number and manifold variety of the extinct Cephalopods, now known only by their polythalamous and siphonated shells, that an exact and accepted determination of their relative position to the body of the framer is most needed.

In the year 1829 LEOPOLD VON BUCH initiated, in his notable memoirs on the *Ammonites*<sup>4</sup>, the definition and nomenclature of the shell-characters by which the species, genera, and families might be defined.

Assuming, and correctly in my judgment, that the shells of an *Ammonite* and a *Nautilus* were coiled in the same direction, he premises:—"Le caractère distinctif entre ces deux genres de Céphalopodes, consiste en ce que le syphon des *Ammonites* est toujours dorsal, et qu'il ne l'est jamais dans les *Nautiles*"<sup>5</sup>. Next, calling attention to the lobed and foliaceous sutures of the *Ammonitic* shells, he defines the parts which he calls "lobes" and "selles" (saddles)—specifying of the former, "le lobe dorsal," "le lobe ventral," and "les lobes latéraux"<sup>6</sup>. Von Buch's descriptions and figures admit of no

<sup>1</sup> "Mollusca," Part I, 4to, p. 6, pl. iv.

<sup>2</sup> Memoir on the Pearly *Nautilus*, &c. 4to, 1832.

<sup>3</sup> Palæontology, 8vo, 1861, p. 97.

<sup>4</sup> Annales des Sciences Naturelles, 8vo, tome xvii. p. 267, tome xviii. p. 417.

<sup>5</sup> Ib. p. 268.

<sup>6</sup> Ib. ib.

doubt as to his conclusion that the outer convex curve was the "dorsal" one, the inner concave curve the "ventral" one, in both *Nautilus* and *Ammonites*.

Such, indeed, seemed the obvious relations to back and belly of the *Nautilus*-shell before the structure and position of its framer were made known. And it should be remembered that my conclusions on the latter point were inferential, a mere fragment only of the shell having been left attached to the unique specimen submitted to my scalpel in 1832.

Accordingly, in 1835, M. DE BLAINVILLE<sup>1</sup>, adopting Von Buch's view of the "dorsal" position of the siphuncle in *Ammonites*, and conceiving the shell of *Spirula* to be convoluted in the same direction as in *Nautilus*, characterizes its siphuncle as "ventral," and that of the Ammonite as "dorsal."

In his applications of these views of relative position to the Ammonites, with little change of the families into which these fossils had been arranged by Von Buch, he proposes new names for them, and adopts the shape and proportions of the outer curve or border of the shell as the family characters. Thus, when such outer, and in my view *ventral*, curve of the shell is broad, as in *Ammonites dilatatus*, a family of "*A. latidorses*" is diagnosed; a reverse proportion, as shown in *Ammonites discus*, characterizes the family "*A. compressidorses*;" but neither these families, nor those of the "cavidorses," "crisidorses," "lævidorses," &c. have gained currency or acceptance.

ALCIDE D'ORBIGNY<sup>2</sup> adopts the view of relative position, the terminology, and in the main the classification proposed by Von Buch.

By MORRIS<sup>3</sup> and ANSTED<sup>4</sup> the aspects of the Nautiloid and Ammonitoid shells propounded by Von Buch are retained. Prof. Ansted associates *Spirula* with *Nautilus* in his family NAUTILACEA, and writes:—"The next point of difference to be attended to is in the siphuncle; and it is one both of position and magnitude. In the genera of the first family, NAUTILACEA, this important part is sometimes ventral, or on the inner margin, more frequently central, and is very rarely observed to approach the dorsal or outer margin. On the other hand, it is almost always very near the dorsal margin in the AMMONEATA, and sometimes is actually placed outside, in a channel opened for it, and projecting from the back of the shell in the shape of a keel"<sup>5</sup>.

In fact, to have propounded that the siphuncle in the Ammonitidæ was *ventral*, as in *Spirula*, would have implied that the shells were coiled in reverse directions—an assumption seemingly held to be too

<sup>1</sup> Prodrôme d'une Monographie des Ammonites, 8vo, 1840.

<sup>2</sup> Paléontologie Française, 8vo, 1842, p. 185:—"Les lettres suivantes, les mêmes que celles qu'emploie M. de Buch, indiquent toujours les mêmes parties dans les figures—*c. g.* D. lobe dorsal, V. lobe ventral," &c.

<sup>3</sup> "On some new Species of the Genus *Ancyloceras*" ("The ribs ornamented with two conical tubercules on the dorsal part"), Ann. & Mag. of Nat. History, 1845, vol. xv. p. 32, pl. vi. figs. 3, *a, d.*

<sup>4</sup> Observations on the Animals inhabiting multilocular Shells, 8vo.

<sup>5</sup> *Ib.* p. 278.

extravagant for adoption. And yet, if the Ammonite was tetrabranchiate like the Nautilus, no other conclusion could logically be drawn.

Accordingly, such view is formally repudiated by the experienced zoologist Dr. J. E. GRAY, in his paper "On the Animal of the *Spirula*"<sup>1</sup>. "The examination," he writes, "of this animal confirms me in the opinion which I expressed in the 'Synopsis of the British Museum' (1840, p. 149), that the Ammonites, from their texture and the small size of the last chamber, are internal shells and should be arranged with the decapodous Cephalopods, being chiefly distinguished from the *Spirula* by the siphon being always on the dorsal margin of the whorls and the septa foliated on the edge. I am aware," he adds, "that this opinion is not in conformity with the ideas of many zoologists and comparative anatomists; for Mr. Owen, in the last arrangement of these animals (Todd's Encycl. Comp. Anat.), though he places the *Spirula* with the *Dibranchiate* Cephalopods, places the *Ammonites* with the *Tetrabranchiate* next to *Nautilus*" (p. 259).

Before recapitulating the grounds on which it was inferred that the *Ammonitidæ* were external shells, I will, finally, cite the valuable Memoirs of the Geological Survey of India, published under the direction of the accomplished and lamented Superintendent of the Survey, THOMAS OLDHAM, LL.D., F.R.S., in which the sanction given to the views of Gray and before-cited authors as to the aspects of the shells of the Ammonites has mainly induced me to offer the present elucidation of the grounds on which I still hold the contrary opinion, viz., that the siphuncle in the *Ammonitidæ* is "ventral" or "margino-ventral," as it is in *Spirula*, but that it is "external" in the one and "internal" in the other, through the reversed direction of the spiral whorls.

In the "Monograph of the Cretaceous *Cephalopoda* of Southern India," the preparation of which was confided to the accomplished naturalist F. STOLICZKA, too early lost to science, he premises the following characters of the *Ammonitidæ*:—

"Animal not known: shell spiral, more or less involute with numerous regularly (?) and gradually increasing whorls in the same plane, many-chambered, the last or body-chamber extending generally over about two thirds of the last whorl. The margins of the septa are deeply divided into lobes and saddles, the first having their subdivisions always pointed, the latter more rounded. The dorsal lobe is divided by a small saddle into two parts, corresponding to the siphuncle: in the regular forms of Ammonites this is always placed in the middle of the back; the siphuncle is also similarly placed inside the shell."

It is to be observed, however, that the author associates the *Ammonitidæ* in the same order "TETRABRANCHIATA" with the *Nautilidæ*; and it would seem therefore that he entertained the doubts originally expressed by Gray<sup>2</sup> and supported by Grant<sup>3</sup> as

<sup>1</sup> Annals and Magazine of Natural History, vol. xv. 1845.

<sup>2</sup> Phil. Trans. 1833, p. 774.

<sup>3</sup> My description and figures were called in question, with more detail, by

to the correctness of the position assigned by me to the soft parts of *Nautilus* in the shell<sup>1</sup>; but the sole reason assigned by Stoliczka for adhering to Von Buch's view of the position of the shell and his consequent denomination of its parts is the following:—"Our descriptions are of the shell (*Am. testa*), not of the animal which was living in it, and which we know not"<sup>2</sup>.

We shall never know the organization of that animal *ex visu*. But there are, in respect of the Ammonite as of most extinct animals, other sources of knowledge in kind and degree sufficient to decide such a question as the relations of soft parts to shell in a Molluscan species.

With regard to those relations in *Nautilus* I may merely cite the subjoined works on its anatomy confirmatory in the main of my own, and fully so in regard to the relative position of the soft parts to the shell<sup>3</sup>.

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the accomplished Professor of Comparative Anatomy in University College, Dr. ROBERT E. GRANT, F.R.S., and begat a general belief, in 1833, that I had placed the animal of the Pearly Nautilus in a position the reverse of the real one, in the 'Memoir' of 1832. In the report of the Lecture on the Shells of the Cephalopoda, given in the 'Lancet,' vol. i. 1833, with the sanction and revision of the Professor, Dr. Grant remarks:—

"The exact position of the animal in the recent *Nautili*, *Spirulæ*, and other polythalamous spiral shells, although important in the interpretation of the fossil forms, has not yet been satisfactorily observed by naturalists. In our present uncertainty, therefore, regarding the position of the living Cephalopods in these convoluted shells, we can only be guided by analogy."

That which guided Dr. Grant to his conclusion he illustrated by figures of sections of the external shell of *Nautilus* and of the internal shell of *Sepia* (p. 506), and explained them as follows. Comparing the layers of the "cuttle-bone" to the septa of the Nautilus shell, he states:—"These layers begin in the *Sepia* by forming a small hollow shell, which receives into its interior another hollow shell; this receives within it a third and a fourth hollow shell; and so they go on in the first stages of its growth. If these cones continued thus to extend outwards, and with an oblique direction, turning on the same vertical plane, they would have formed a convoluted suborbicular shell, like that of the Ammonite or the Nautilus. Where, then, in this so convoluted shell of the *Sepia*, would have been the convex outer border of the shell, or the upper lip, with relation to the body of the *Sepia*? The *Sepia* would have looked forwards over the spire from the last-formed chamber, keeping the exterior convex part of the chamber" (answering to B in fig. 3) "or the upper lip extending across its back, as in all other known orbicular shells of Pteropodous and Gasteropodous Mollusca." (P. 509.)

<sup>1</sup> Memoir, *ut suprâ*, pp. 12, 44, pl. i.

<sup>2</sup> *Op. cit.* p. 44. So, likewise, affirms a later writer:—"We have *only the shells* preserved to us. We know nothing of the animals."—H. Woodward, Geol. Mag. vol. v. p. 497.

As well might it be affirmed of *Anoplotherium*, e. g.:—"It must always be borne in mind, when arguing from these early fossil remains, that we have *only the skeleton* preserved to us. We know nothing of the soft parts."

<sup>3</sup> VALENCIENNES, M. A. "Nouvelles Recherches sur le Nautile flambé (*Nautilus pompilius*, Lam.)," Archives du Muséum d'Histoire Naturelle, Paris, 4to, tome ii., 1841, p. 275, pls. viii., ix., x.

VAN DER HOEVEN, J. "Contributions to the Knowledge of the Animal of *Nautilus pompilius*," Trans. Zool. Soc. vol. iv. p. 21, pls. 5, 6, 7, 8.

VROLIK, W. "Lettre sur quelques points de l'organisation de l'animal du Nautile flambé," Mémoires de la Soc. Linnéenne de Normandie, tom. x., 4to, 1855, pp. 1-18, pls. i. and ii.

A colleague of Stoliczka, accepting the recorded structure and relative position of *Nautilus*, frames his nomenclature of the parts and aspects of the fossil shells of the *Nautilidæ* accordingly<sup>1</sup>, the grounds for such being those of positive or direct evidence from dissection. I am led, therefore, to submit remarks on the guiding knowledge in regard to the structure and shell-relations of the extinct Ammonites, which may be gained from negative or inductive testimony.

J. E. Gray, we have seen, deemed that testimony to be such in kind and amount as to warrant his rejection of the affinity of *Ammonites* to *Nautilus*, and his adoption of the association of *Ammonites* with *Spirula* in the Dibranchiata order of Cephalopoda.

Examples of unmutilated Ammonite shells are, indeed, very rare; seldom is a specimen acquired with any considerable proportion of the last chamber. Yet some such were to be seen in an accessible museum in London long anterior to 1845.

A bisected specimen of the *Ammonites obtusus*, Sow., in the Hunterian collection (No. 188), shows well the extent of the last or inhabited chamber of the shell, and the effects of the influence of the animal matter of the decaying Cephalopod upon the petrifactive processes after death. The liassic clay has penetrated as far as the retracted soft parts of the Ammonite permitted; the decomposing mollusk has been partially replaced by crystals of spar discoloured by the pigmental or carbonized parts of the animal; the spar which has more slowly infiltrated through the pores of the shell into the air-chambers is of a much lighter colour.

In the same collection may be seen exemplifications of injury and repair of the cell. In No. 195, *Ammonites goliathus*, D'Orb., from the Oxford Clay, a portion of the shell, at the period when it formed the dwelling-chamber, "had been broken away during the lifetime of the animal, and has been repaired by fresh material, wanting the ribbed structure of the originally formed shell"<sup>2</sup>.

The reparation closely resembles that which recent *Nautilus*-shells occasionally present, and which we know was effected by the formative border of the mantle reflected over the last chamber and applied to the fractured part. No such process could take place in *Spirula*, the mantle of which is muscular, and inapplicable to the last chamber. There is no need of a living Ammonite to assure us that its mantle, like its porcellano-nacreous shell, had the same structure as that of the living *Nautilus*.

<sup>1</sup> Memoirs of the Geological Survey of India, 4to, 1866. "The Fossil Cephalopoda of the Cretaceous Rocks of Southern India: *Belemnitidæ*—*Nautilidæ*," by HENRY F. BLANFORD. "Throughout the following descriptions I have employed the terms *ventral* and *dorsal* strictly with reference to the position of the animal, and therefore in an opposite sense to that in which they were used by palæontologists before the anatomy of the animal was known," p. 7. (And Mr. Blanford might have added "long after."—R. O.)

<sup>2</sup> Catalogue of Fossil Invertebrata, Mus. College of Surgeons, London, 4to, 1856, p. 43, in which work I described upwards of 350 specimens, illustrative of the different families and genera of *Ammonitidæ*, collected by JOHN HUNTER in the last century.

The perfect specimen (Plate LX. fig. 1) of the last chamber of the Ammonite was derived from that eminently conservative matrix, the lithographic slate of Solenhofen, Bavaria. The extent of the outer curve of the dwelling-chamber to the outer border of its floor (the last septum,  $x$  to  $y$ ) is 4 inches; the extent of the outer curve of the chambered part of the shell to the inner border of the chamber-floor (last septum,  $y$  to  $z$ ) is 6 inches. In the *Nautilus pompilius* transmitted in its perfect shell to Prof. Vrolik the corresponding admeasurements are 7 inches 9 lines and 11 inches 6 lines. The correspondence in the proportion of the dwelling-chamber to the camerated part of the shell in the Ammonite and Nautilus is thus, as in numerous other instances, shown to be instructively close.

In the last chamber of *Ammonites lingulatus*, moreover, as if to proclaim to the most sceptical its function of lodging its constructor, is preserved the only fossilizable part of such (ib. fig. 1,  $o$ ).

Since the publication of the 'Paléontologie' of Pictet<sup>1</sup>, who refers the Trigonellites to the Cirripeds, abundant evidence has been obtained of the accuracy of the opinion of Volz<sup>2</sup>, that the *Trigonellites* of Parkinson<sup>3</sup> (*Aptychus* of v. Meyer<sup>4</sup>) were parts of the animal of the Ammonite, and stood in opercular relation to the shell of that extinct Tetrabranchiate. Pictet takes no note of the confirmation contributed by Morris to the Volzian examples of Trigonellites within the last or dwelling-chamber of *Ammonites*, in the portion of an *Ammonites walcotti* in which "the *Aptychus*, of a corneo-calcareous nature, was found imbedded in the matrix filling the last chamber about 6 inches from the aperture"<sup>5</sup>.

This common, though not constant, position led some palæontologists to surmise that the Trigonellites might be parts of the *Ammonites*' gizzard, like the triturating plates in *Bulla lignaria*. M. Valenciennes believed them to be lateral supports of the funnel<sup>6</sup>. Van der Hoeven "hazards the opinion that the two juxtaposed fossil shells, known by palæographers as *Aptychus*, were two shelly supports of the hood of *Ammonites*" (Trans. Zool. Soc. vol. iv. p. 22). In this opinion I concur; but it has been rejected by some experienced students of the extinct polythalamous shells. Keferstein and Waagen<sup>7</sup>, *e. g.*, deem the Trigonellites to be sexual characters, and to have served as protective plates of the nidamental glands of the female Ammonite. Waagen adduces, in support of this view, the

<sup>1</sup> Traité de Paléontologie, &c., vol. ii. p. 551, 8vo (1854).

<sup>2</sup> "Sur le *Belopeltis*," in Mémoires de la Soc. d'Hist. Nat. de Strasbourg, tome iii. (1836).

<sup>3</sup> 'Organic Remains of a Former World,' 4to, 1811, p. 184, pl. xiii. figs. 9-12.

<sup>4</sup> Nova Acta Acad. Nat. Cur. t. xv. pt. 2, p. 125, pl. lviii. (1831).

<sup>5</sup> "Note on *Aptychus*," in Ann. & Mag. Nat. Hist. vol. x. (2nd ser.), p. 356, pl. v. D. fig. 1.

<sup>6</sup> "Je crois qu'il faut admettre que l'entonnoir de l'ammonite, s'il était formé de deux valves, ne contenait pas de cartilage interne; mais que cette pièce était remplacée par un organe extérieur composé de deux pièces paires symétriques comme le sont les aptychus."—Ib. p. 304.

<sup>7</sup> "Ueber die Ansatzstelle der Haftmuskeln beim Nautilus und Ammoniten," Palæontographia, 4to, p. 185, taf. xxxix., 1871.

correspondence of the relative position of the *Aptychus*<sup>1</sup>, in the body-chamber, to that of the nidamental glands of *Nautilus pompilius*<sup>2</sup> to the shell; and he deems each valve of *Aptychus* to have been applied to a lateral lobe of the nidamental gland<sup>3</sup>. But these lateral lobes are divided from each other by a part of the middle lobe<sup>4</sup>, while the valves of the *Aptychus* are usually in contact (as in Plate LX. fig. 1, *o*), or may be suturally united along the mid line (as in *ib.* fig. 2, *o*). But to return to Waagen's argument from position in the fossil shell. In the course of decomposition after death the calcareous plates would be likely to gravitate or sink deeper into the body-chamber than their natural position in the living Ammonite. So sinking, they would rather lodge or settle in the hollow of the outer (ventral) wall of the body-chamber (B) than upon the involute convexity on the opposite (dorsal) wall (A). Moreover there are examples (as in Plate LX. fig. 2) in which the Trigonellites (*o, o*) have been found in an opercular relation at the mouth of the shell. And, considering the movements to which an Ammonite must have been subject from the time of its death to the solution of the soft parts and final imbedding of the shell in the matrix or seat of its petrification, one is prepared for the rarity of the conservation with the shell of its loose operculum, and for the still more rare retention of the *Aptychus* in its original position. Waagen admits that there are five specimens of Ammonite in the Munich collection exhibiting this position<sup>5</sup>. He, however, contends that the breadth of the aperture of the body-chamber is less, in certain Ammonites (*A. steraspis*, e. g.), than the united breadth of the aptychal plates. But so, likewise, if the side lobes of the hood of *Nautilus*<sup>6</sup> were outstretched horizontally, it would exceed the breadth of the outlet of the dwelling-chamber in *N. pompilius*. But the side lobes of the hood are bent back obliquely in order to close the dorsal side-curved borders, or notches, of that part of the shell-aperture, just as the aptychal lobes or valves are bent down in Plate LX. fig. 2, *o, o*.

It may be further remarked, in respect to the nidamental glands, that they are subject to seasonal changes, and gain the relative bulk with which the size of the aptychal plates accord only at the period of discharge of the impregnated ova, for which they have to furnish the protective coat or nidus. Such seasonal change is exemplified in the figure of these glands given in the 'Memoir on the Nautilus' of 1832, and in that which is shown in Taf. xix. of Waagen's Treatise, 1871. Moreover, in not one of the existing genera or species of Cephalopod, *Nautilus* included, in which these glands are superadded to the more essential organs of generation, are they encumbered in any way or degree with such calcareous plates as Keferstein's hypothesis applies to them in the Ammonite.

<sup>1</sup> Palæontographia, 1871, taf. xl. fig. 4.

<sup>2</sup> See Memoir on the Nautilus, 1832, pl. i., e.

<sup>3</sup> *Ib.* pl. viii. fig. 10, *b, b*.

<sup>4</sup> *Ib.* *ib.* *a*.

<sup>5</sup> "Unser Museum besitzt gegen 100 exemplare von Ammoniten mit erhaltenen *Aptychus*; unter dieser ganzen Anzahl sind 5, welche den *Aptychus* in senkrechter Stellung am Ende der Wohnkammer liegend haben" (*op. cit.* p. 192).

<sup>6</sup> Memoir on the Nautilus, 1832, pl. iii. fig. 1, *g, g*.

In the application of the anatomy of the constructor of the Pearly Nautilus to the solution of the problem of the nature and function of the Trigonellites, I was led to regard them as the homologue of the organ, or a portion of the organ, in *Nautilus*, which is "of a fibrous texture, resembling dense corium," called from its shape and position the "hood" (Plate LX. fig. 3, *e*), and which, when the animal had withdrawn into its dwelling, "would serve as a rigid defence at the outlet of the shell"<sup>1</sup>. It needed only that this part should be more or less calcified to form the preserved portions of an operculum like that ascribed to the Ammonite. If, for example, calcification had commenced in each half of the symmetrical "hood," and had stopped at the mid line (where the hood is thinnest), the pair of the there-often-suturally-joined symmetrical pieces of the *Aptychus* would have resulted. The relative size of *Aptychus* agrees with that of the shell. It has been found to measure 7 inches 6 lines in length and 6 inches in breadth in gigantic Ammonites<sup>2</sup>. It may be doubted whether the nidamental glands ever increased in the same ratio; and it is still less likely that they needed such defensive plates in their season of rest and attenuation.

If, therefore, my homology of the symmetrical halves of the *Nautilus*' hood with the parial Trigonellites (*Aptychus*, v. M.) be preferably accepted, the supposition that these parts are calcifications of an Ammonite's hood may be deemed reasonable. That the fibrous basis of the hood was retained in different degrees in the Ammonites is indicated by the simply corneous or chitinous condition of the *Aptychus* which has been preserved in some examples of *Ammonites falcifer*, Sow., and its allies. In other species, as in the *Ammonites lingulatus* (Plate LX. fig. 1, *o*), the lateral calcifications have partially met and joined at the mid line; in a third series these opercular plates are thicker and are there suturally united. This is the case in the small or young specimen of *Ammonites subradiatus*, Sow., in the British Museum, which is described and figured by S. P. Woodward, F.G.S., in 'The Geologist'<sup>3</sup>. As the view of the specimen there given is an oblique side one, I here append a direct view of the aperture of the dwelling-chamber as closed and protected by its operculum (Plate LX. fig. 2, *o*). The correspondence of general shape with that of the "hood" of the *Nautilus pompilius*, as figured in plate iii. fig. 1 of my 'Memoir,' is close<sup>4</sup>.

The conjoined plates of the *Aptychus* (ib. fig. 2, *o, o*) form a triangular disk, of which the base is backward, excavated to receive the involute part of the shell, *p*, with the sides of the base, like the corresponding lobes of the "hood," bent down to cover the laterally extended parts of the wider terminal coil of the shell, *q*. Even in the contrast between the papillose wrinkled outer surface and the

<sup>1</sup> Memoir on the Pearly Nautilus, 1832, p. 12, pl. i. *n*, and pl. iii. fig. 1.

<sup>2</sup> See de Zigno, Memorie del R. Istituto Veneto, tom. xv. tab. viii., 1870.

<sup>3</sup> *Svo*, 1860, p. 328.

<sup>4</sup> Woodward gives the following description of its ammonitic homologue:—"The operculum is flat in the middle, with a slight furrow along the suture, and is much bent down at the hinder corners, where it abuts against the inner whorl of the shell. It is sculptured externally with about twelve angular concentric furrows; the inner surface is smooth."—*ib. ib.*



smooth inner surface of the "hood" of *Nautilus* the resemblance to the "Aptychus" of the Ammonite is carried out. Anterior to the apex of the triangular operculum in the *Ammonites subradiatus* a small portion of the dwelling-chamber (ib. *v*) is left uncovered, through which a slender stream of water might pass from the retracted funnel.

As the soft parts of the *Ammonites lingulatus* decayed and were dissolved the calcareous or opercular parts of the hood (ib. fig. 1, *o*) have subsided to near the bottom of the dwelling-chamber, probably with such change of their original relative position, as exemplifies the value of the demonstration given in the specimen described by Woodward. If an independent centre of calcification were set up in the mid region of the "hood" (*Mem. cit.* pl. iii. fig. 1, *f*), a part corresponding to the *Anaptychus* might result.

In further ventilation of the mooted affinity of *Ammonites* to *Spirula*, it may be remarked that in not one of the examples of *Ammonites* in which the dwelling-chamber has been in any proportion preserved has there been any trace of an ink-bag. Yet fossilization of this or of its secretion is abundantly exemplified in the extinct Belemnites'. Hence the inference may as confidently be drawn, as from a dissection of the animal of the Ammonite, that this Cephalopod lacked, like the *Nautilus*, the singular defensive contrivance with which the more active Dibranchiate Cephalopods were endowed, and that the animal of the Ammonite was compensated, like that of the *Nautilus*, by having an external protective shell into which it could retreat and close the entry against the assaults of an enemy. Moreover, admitting the homology of the "Aptychus" with the "hood," we further learn that the defensive door of the house was "dorsal," and that the relative position of the soft parts to the external shell was the same in *Ammonites* as in *Nautilus*.

It cannot be averred, therefore, in excuse of a nomenclature implying a different and opposite relative position of the soft parts to the shell, that "the animal of the Ammonite is unknown."

To the composite porcellano-nacreous structure by which the Ammonitic agree with the Nautiloid series of shells, and their difference in this character from the simply nacreous structure of the *Spirula*-shell, reference is here made in illustration of the "Law of Correlation." The conformity, in this respect, with the Nautiloid series is maintained under every modification of shape from straight to convolute.

But the persistence with which monographers of these numerous and beautiful fossils, notwithstanding the appeals of Pictet<sup>2</sup> and M'Coy<sup>3</sup>, and the practice of Barrande, adhere to the erroneous views of Von Buch as to which was the dorsal and which the ventral aspect of the shells, has moved me to supplement the original grounds of

<sup>1</sup> Buckland, Bridgewater Treatise, vol. i., 1835; Owen, "On certain Belemnites from the Oxford Clay." Phil. Trans. 1844.

<sup>2</sup> Palæontology, vol. ii. p. 618.

<sup>3</sup> Ann. & Mag. Nat. Hist., 2nd ser. vol. viii. p. 481.

my conclusions on that question by additional or confirmatory evidence from autopsy of the fabricators of the still existing polythalamous and siphoniferous Cephalopods.

Having prevailed upon Mr. Cuming, subsequently to my Monograph on the anatomy of *Spirula* in the 'Zoology of the Samarang,' to permit me to test that anatomy by dissection of his unique specimen, I proceed to point out such structural facts, confirmed by that dissection, as demonstrate the ventral position of the marginal siphon of the internal shell of *Spirula*—and to combine therewith corresponding anatomical observations on *Nautilus*, which, with the demonstrated affinity thereto of *Ammonites*, equally prove the ventral position of the marginal siphon of the external shell of that extinct genus and its allies.

The dorsal aspect of a Cephalopod is determined by the position of the brain and eyes, *i. e.* by that predominating part of the brain which sends off the optic nerves. The ventral aspect is shown by the respiratory funnel (Plate LX. figs. 3 and 4, *j*, and gills, *m*). No malacologist has questioned these conclusions. The proposition might be simplified by stating that the funnel shows the "ventral side" of the animal, and that the opposite one is the "dorsal side."

Accordingly, all who have occupied themselves with the organization of the Cephalopods have pointed out the singular reversed positions of the mandibles as compared with those in such vertebrate animals as repeat the cephalopodic condition of a "beak," as, *e. g.* *Chelonia* and *Aves*.

Instead of the dorsal or upper mandible being the largest and longest, so as to overlap the ventral or under mandible, as in birds, the dorsal mandible, *h*, figs. 3 and 4, is the smaller and shorter one, and is underlapped by the larger and longer ventral mandible, *i*, in all Cephalopods.

So, likewise, the branchiæ, *ib*, figs. 3 and 4, *m, m*, lie in the ventral part of the pallial cavity; and, in short, the several viscera occupy similar relations to back and belly in both Tetrabranchiate and Dibbranchiate Cephalopods<sup>1</sup>.

The aspects of the body being thus abundantly and unmistakably determined, they can be as unequivocally predicated of the shell under whatever shape or proportion it may be present.

The portion of the shell of *Nautilus* which extends from the fundus of the last chamber, along the dorsal aspect of the mantle, as from A to A', fig. 3, is the "dorsal wall" of such shell, and so must be its continuation backwards.

The portion of the shell of *Spirula* which bears the same relation to the dorsal aspect of the body is the "dorsal wall" of the shell, A, A', fig. 4; while that part of the last chamber which protects the ventral side of the muscular and visceral mass which it contains, small though it may be, is part of the "ventral wall" of the shell, B, and so must be its continuation as far as it extends, viz. to the "protoconch" (fig. 5, *a*) or incipient nuclear chamber.

<sup>1</sup> See "Supplementary Observations on the Anatomy of *Spirula*," in *Annals and Magazine of Natural History* for January 1879.

Accordingly, the dorsal wall, A, of the spiral shell of *Spirula* describes a convex curve, the ventral wall, B', a concave curve. In *Nautilus* the curves are reversed. If the shell of *Orthoceras* or *Baculites* were curved so as to present the same relative positions of convexity and concavity which exist in that of *Spirula*, they must have been coiled in a reverse direction to that which is presented in the shells of *Nautilus* and *Ammonites*.

Admitting that the siphon in *Ammonites* and *Spirula* are both "ventral" or "ventro-marginal," yet the relative position to the shell is so contrasted as to call imperatively for terms indicative of such contrast. And such terms are obvious. Of a convolute shell the convex curve is the *outer* one, the concave curve the *inner* one, whatever may be the relative position of its constructor.

Had Von Buch been content to call those curves in a convolute Ammonite "external" and "internal," and to define the position of the siphon as "externo-marginal" and "interno-marginal" respectively, his terminology would have stood and been unquestioned to the present day. But he proceeded to a conclusion as to their relations to the constructors of the shells; and, as no specimen of either a *Nautilus* or a *Spirula* had been dissected in 1829, such conclusion could only be a guess.

So probable, however, seemed the guess, that his most experienced contemporaries, De Blainville, Grant, and Gray, after the organization of the Pearly *Nautilus* had been made known, preferred, as we have seen, the opinion of the conchologist to that of the anatomist, and deemed the latter to have reversed the true position of the animal of the *Nautilus*<sup>1</sup>. And, with most<sup>2</sup>, the nomenclature of the parts of the shell of the *Ammonitidæ* has continued in concordance with that opinion to the present day.

If, however, the facts and inferences now submitted to the Zoological Society should be accepted with their logical applications in conchology, and the siphon in both *Ammonites* and *Spirula* be acknowledged to be "ventral," or "ventro-marginal," nevertheless the different positions of the siphon in these shells and in that of *Nautilus* demand to be defined by distinctive terms. And these are easy, obvious, and incontrovertibly applicable. The siphon in the *Ammonitidæ* is "external," "externo-marginal," or "ecto-marginal." The siphon in *Spirula* is "internal," "interno-marginal," or "ento-marginal." The siphon in the *Nautilidæ* may be "central," or "subcentral;" and if the latter, either "ectocentral" or "entocentral," according as it deviates from the typical central position toward the

<sup>1</sup> See notes 2 and 3, p. 957.

<sup>2</sup> Even in S. P. Woodward's classical 'Manual of Mollusca,' 12mo, "dorsal" and "ventral," are used as synonyms of "external" and "internal." Thus the genus *Ammonites* is characterized by "siphuncle dorsal" (p. 94, and p. 197, ed. 1868). The genus *Goniatites* is characterized by "siphuncle dorsal" (p. 93). The experienced Editor, in a later edition of the 'Manual of the Mollusca,' in his 'Appendix' (12mo, 1868) approximates to the conclusion here advocated, by amending the character of Fam. iii.—*Ammonitidæ*, thus:—"Siphuncle—convexo-marginal?" (p. 10). If the present paper should serve to dissipate Mr. Tate's remaining doubt it will be an acceptable return for my labour.

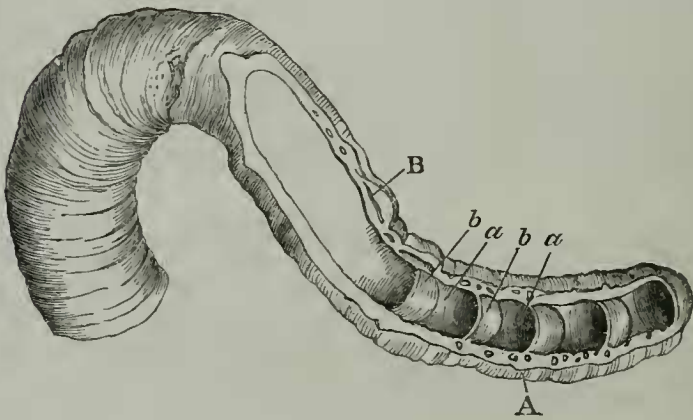
external or internal part of the shell : in some rare cases (*Cryptoceras*) the siphuncle is ectomarginal, as in *Ammonites*; and in still rarer instances (*Clymenia*) it is entomarginal, as in *Spirula*. There are also species in which it begins by being marginal, and gradually shifts to the more typical position as the shells grow and the number of the septa increases.

In the *Nautilus imperialis*, e. g., the siphuncle is at first, i. e. along the first twenty chambers, entomarginal, or near the concavity of the shell-curve, as in *Spirula*; but in opposite relations to the back and belly of the animal. After the twentieth chamber the siphuncle gradually gains the central or excentral position<sup>1</sup>. *Nautilus ziczac* shows a similar structure. The immature position of the siphon in the existing *Nautilus* was longer retained in the old Tertiary species.<sup>2</sup>

Various suggestions have been made as to the efficient as well as final cause of the successively vacated parts called "chambers," with their partitions and connecting siphon, in the polythalamous and siphoniferous shells of Cephalopods.

In elucidation of this question, much mooted by different writers<sup>3</sup>

Fig. 1.



*Vermetus gigas.*

Section of chambered part of shell.

after the publication of my Memoir on the Pearly Nautilus, I adduced the instances of such vacuities or chambers in the Mollusca,

<sup>1</sup> Catalogue of Hunterian Cephalopoda, 4to, no. 137, p. 32.

<sup>2</sup> See the just remarks of Barrande on the variation of the siphuncular character in certain nominal species (*Céphalopodes Siluriens de la Bohême*, 8vo, 1867, p. 24).

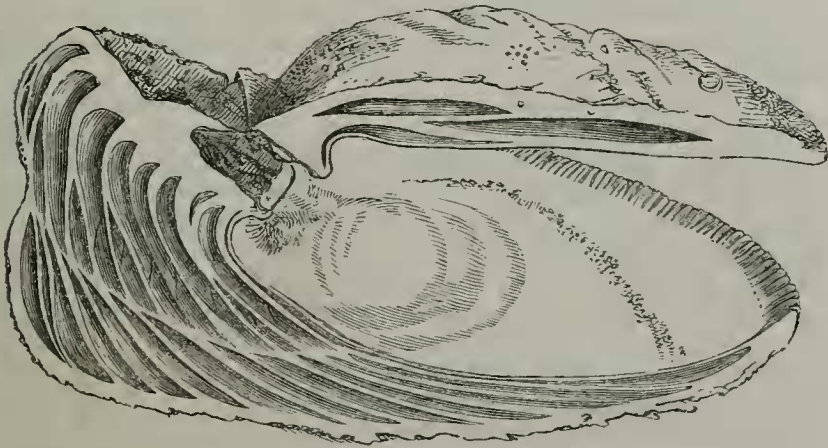
<sup>3</sup> Buckland, 'Geology and Mineralogy considered with reference to Natural Theology.' 1835, vol. i. p. 329. De Blainville, "Sur l'usage du siphon des coquilles polythalamées," *Annales françaises et étrangères d'Anatomie et de Physiologie*, t. i. 1837.

as, e. g., *Fistulana clava*, *Vermetus gigas*, *Helix decollata*, the *Ostreae*, *Estheria*, and other Bivalves, more especially the *Spondylus varius*<sup>1</sup>.

In *Fistulana* and the gastropodal *Vermetus*, the animal periodically withdraws itself from its dwelling-chamber; the growth of the walls is continuous and uninterrupted; but a thin new floor is formed at some distance from the old one left behind, and a series of chambers fig. 1, *a a*, results. If the calcareous deposit had been continuous in every part of the shell, a solid tract would have been left behind, as in *Magilus*. The successive floors or "septa" in *Vermetus* (fig. 1, *b b*), extend freely across and are concave toward the outlet; they are entire and adherent only by their marginal circumference to the shell-wall (A, B). The contents of the chambers in the living *Vermetus* are unknown. Both chambers and partitions are the consequence of a mode of shell-growth; physiological ken stretches not beyond this.

In *Spondylus varius* (fig. 2) the "septa" are not continued freely across the shell, but are united together near the middle or centre of their extent, at the position of the impression of the adductor

Fig. 2.



*Spondylus varius*.

Section of chambered part of shell.

muscle. This, in the forward movement of the mollusk, does not quit its attachment to the nacreous layer of the valves; whilst the pallial lobe, except at its circumference and where it adheres to the adductor, can and does detach itself from the surface of the valve about to be abandoned, in the progressive growth of the visceral mass. The mantle at each period of repose, then secretes on the fluid occupying the deserted part of the shell, the new septum or

<sup>1</sup> Proc. Zool. Soc. 1837, p. 63. See also H. Woodward, "On the Structure of the Shell of the Pearly Nautilus," Report of the British Association, Liverpool, 1870, Trans. of Sections, p. 128.

basis of support of the mollusk. Thus the septa, as they are successively formed, adhere, not only to the circumference of the growing valve, but to a central part of the preceding septum, and for an extent more or less corresponding to the circumference of the correspondingly advancing adductor muscle.

If the adductor were a tube instead of a solid mass, the central confluent part of the septa would be perforated, and a siphon would result, the calcareous walls of which would be continuous, as in *Spirula*, *Nautilus striatus*, the Orthoceratites, &c.

The contents of the deserted chambers in *Spondylus varius* are sea-water with an increased proportion of the saline ingredients.

The efficient cause of the forward movement of the *Spondylus varius* appears to be the need of a shell of a size suitable to the growing bulk of the animal, coupled with the frequent fixation of the lower valves of the young shell to an overcrusting mass of coral, in advance of which the growing shell must increase. Such increase and the testaceous provision for it are not, therefore, attributable to special expansion of one organ, but to the concomitant growth of the whole of the soft parts of the Palliobranch.

It has been suggested that the periodical increase of the ovarium or testis might initiate and constrain the forward movement of the soft parts in the Cephalopods with chambered shells, and that a polythalamous structure is related conditionally to the generative function<sup>1</sup>.

But it will be observed, in both *Spirula* and *Nautilus*, that the formation of the chambers commences from the embryonal cup (protoconch, fig. 5a, p. 973), and continues through an early period of growth antecedent to the acquisition of the procreative function, or the adult stage of existence—and, moreover, that those early chambers are relatively deeper<sup>2</sup> than the succeeding ones, indicative of a more extensive forward movement of the soft parts, in accordance with the more rapid growth of the animal which characterizes the period of nonage, when all the assimilative functions are concentrated on general increase and no degree of that power is diverted to the development of special organs, such as the testis or ovarium.

The last or open chamber of *Nautilus*, and, by analogy of size and certain known contents, in *Ammonites*, was occupied by the entire soft parts. In *Spirula* it contains only the hind end of the liver and portions of the origins of the retractor muscles of the head and funnel. It has been stated to contain the ink-bladder in *Spirula*<sup>3</sup>; but in my dissections of that Cephalopod made subsequently to that detailed in the 'Zoology of the Voyage of the Samarang,' I find the same positions and relations of the ink-bag as are described and figured in that monograph<sup>4</sup>.

<sup>1</sup> Prof. Seeley, Proceedings of the British Association, Bath, 1864, Section Zoology, "Nautiloid shells," 8vo, p. 229.

<sup>2</sup> By depth is meant the diameter from septum to septum; by breadth that between wall and wall.

<sup>3</sup> Woodward, 'Manual of Mollusca,' p. 77.

<sup>4</sup> "A very minute pyriform ink-bag, z, is situated close to the rectum; and its duct opens within the verge of the anus" (p. 10, pl. iv. fig. 11).

As to the function or "final cause" of the chambers, I hold by the opinion expressed in my original memoir<sup>1</sup> and in the 'Catalogue of the Fossil Cephalopoda in the Hunterian Museum,' 4to, ed. 1856<sup>2</sup>, viz. that they so affect the specific gravity of the active, highly organized, cephalopodous mollusk, as to enable it with little effort to rise, in the case of the *Nautilus*, from its habitual position at the bottom of the sea—and in the case of the *Spirula*, to sink from its more usual zone at or near the surface,—such vertical movements being executed, like the horizontal ones, by means of the hydrostatic mechanism worked by the muscular forces of the mantle and funnel.

The contents of the vacated chambers in *Nautilus pompilius* are stated to be nitrogenous gas. Neither the contents nor the vital properties of the siphuncle are yet known; an artery and vein are assigned for its life and nutrition, and to extend a low degree of the vivifying influences to the shell. Vrolik confirms the existence of the siphonal artery described and figured in pl. vi. fig. 1, 14, of my 'Memoir,' and repeats this illustration in his pl. i. fig. 2, "i, artère allant au siphon"<sup>3</sup>.

The siphonic artery sends off, according to Keferstein, branches to the mantle which lines the bottom of the body-chamber before penetrating the siphon. Waagen figures the impression of these arterioles on the shell-surface<sup>4</sup>; and it has been suggested that these vessels may supply, by secretion, the chamber-gas which I inferred might occupy the space left free on the recession of the visceral sac from the chamber-floor prior to the formation of a fresh septum<sup>5</sup>.

Thus, in the analysis of the structure of chambered shells, we find:—septa simple, distinct, attached only by their circumference (woodcut fig. 1, p. 966); septa attached, subcentrally, to each other, as well as by their circumference to the shell-walls (fig. 2, p. 967); septa (fig. 3 *b*, p. 907) attached marginally to the shell-walls, *A*, and also to each other by tubular prolongations, *c*, with an organized, vascular, membranous canal, *d*, traversing such testaceous tube; septa with a calcareous siphuncle consisting of a series of superimposed, elongate, funnel-shaped tubes, with the wide end directed toward the aperture of the shell, as in *Spirula* (fig. 4, p. 971), or in the opposite direction, as in *Bathmoceras*. The more complex siphons of Orthoceratites will be presently referred to. Finally, we see in the existing *Nautilus* the shelly tube interrupted, forming the "collar of the siphon," and the septa and chambers traversed by a lime-coated membranous canal running through the interrupted shell-tube (Plate LX. fig. 3, *c*, *d*).

<sup>1</sup> "From the adhesion of the entire circumference of the mantle to the shell by means of the 'horny girdle' ('*annulus*,' Waagen, *op. cit.*), I am inclined to suppose that the whole of the chambers are excluded during the life-time of the animal from external influence, and are filled only by exhalations or secretions from the animal."—*Memoir on the Nautilus* (1832), p. 47.

<sup>2</sup> "The proportion of the air-chambers to the occupied dwelling-chamber of the *Nautilus* is such as to render the whole animal of nearly the same specific gravity as the surrounding water."—*Catalogue*, p. 29.

<sup>3</sup> Mémoires de la Soc. Linnéenne de Normandie, tom. x. 1855, p. 17.

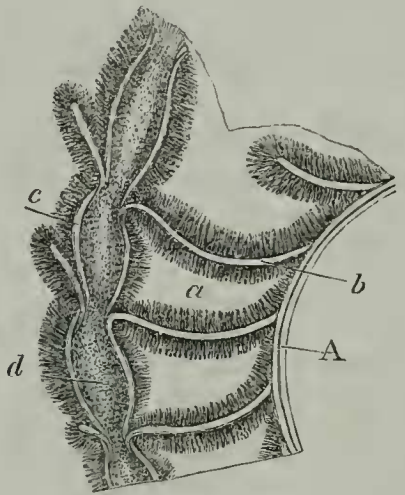
<sup>4</sup> Waagen, *op. cit.* Taf. xxxix. fig. 4.

<sup>5</sup> *Op. cit.* 4to, 1832, p. 47.

For the different views which have been propounded as to the nature and function of this complex siphon, reference may be made to the authors cited, p. 966. Some of these views were based on the partial knowledge of its structure at the date of the first dissection of the Pearly Nautilus.

The true structure of the siphon in *Nautilus pompilius* is rarely preserved; the somewhat loose calcareous matter by which the membranous part is incrustated is commonly lost with that part in the dry cast-off shells. The calcareous incrustation is apt to be dissolved, like that of the mandibles in Valenciennes's specimen, by the acetous change of the alcohol when charged with soluble parts of the animal during a prolonged transit to a European museum.

Fig. 3.



*Nautilus striatus.*  
Section of part of shell.

When cataloguing, in 1854 and 1855, the Hunterian Cephalopods, I saw sufficient to supplement the description of the siphon in the 'Memoir on the Nautilus,' as follows:—"An artery and vein are assigned for its life and nutrition, and to extend a low degree of the same influences to the shell; but the structure of the membranous siphuncle presents, beyond the first chamber, an inextensible and almost friable texture, apparently unsusceptible of dilatation and contraction; it is also coated beyond the extremity of the short testaceous siphuncle with a thin calcareous deposit"<sup>1</sup>. The fact of this incrustation has been ascertained, independently, by Prof. Vrolik. The subject of his memoir in the volume cited in note 1, was

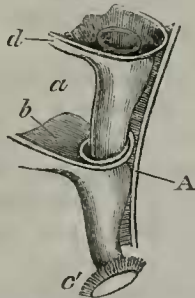
<sup>1</sup> Descriptive Catalogue of the Fossil Organic Remains of the Invertebrata contained in the Museum of the Royal College of Surgeons of England, 4to, 1856, p. 29. This volume was not issued until all the invertebrate fossils were described; and the first sheets were printed off before the 'Mémoires de la Société Linnéenne de Normandie,' vol. x. 1855, came to my hands.



in such a favourable state of preservation that the calcareous incrustation of the membranous siphon was entire, and formed the subject of the continuous inflexible composite tube represented in pl. i. fig. 5, *a, b*, in that accomplished naturalist's memoir. The notion of the dilating and contracting action of the siphon of the *Nautilus* upon its contents, whatever these may be proved to be, could be no longer entertained. Vrolik, confirming by his dissection the existence of the siphonal artery, infers, like myself, the coexistence of a returning channel, although no vein with definite tunics was demonstrable in either dissection.

Evidence of the capillary ramifications of the siphonal artery upon the pallial membrane lining, as periostracum, the interior of the shell-chambers has been adduced by the careful observers Keferstein and Waagen; but such channels of vitality are not supposed to penetrate the shell itself. Molluscous shells, like avian feathers and mammalian hairs and teeth, do not receive the terminal divisions of the blood-vessels supplying their several pulps or formative organs. Ordinary or hard dentine, like conchine, piline, and plumine, is extravascular, but not, therefore, extravital. The percolation by cellular passages and intervals of a rarer, plasmal exudation from the vital

Fig. 4.

*Spirula australis.*

Section of part of shell, magnified.

fluid renders intelligible the change and movements of pigment in the same hair and in the same feather. As the dentist distinguishes dead from living teeth, so the conchist regulates his estimate of the value of a "dead" as contrasted with a "living" shell. The estimable researches of Carpenter on the modifications of microscopic texture in shells parallel those that have demonstrated as many modifications of the microscopic channels by which the plasma percolates the dentinal as it does the chonchinal tissues<sup>1</sup>.

The high organization of the Cephalopods compared with other

<sup>1</sup> Laborious studies of this kind in quest of truth beget a modest reticence and an abstaining from such dogmatic utterances as those of the writer who "denies the possibility of the siphuncle maintaining the vitality of the shell, because it is certainly a non-vascular structure."—"Recent and Fossil Cephalopods," *Geological Magazine*, vol. v. p. 490.

mollusks suggests to the physiological mind the probability that some corresponding step in advance of the ordinary condition of a testaceous defence would be likely ; and the retention of the parts of such defence vacated in the course of growth, with the superaddition of a vascular by-way running through the whole, verifies such anticipation of the means whereby the camerated and siphoniferous shell is thus brought into closer harmony with the rest of the organic structure.

When the first simple, single-chambered, nuclear dwelling is added to and, in part, abandoned, a closer connexion is therewith preserved than in *Vermetus*, *e. g.* ; and, as the artery penetrating the membranous siphon continued from the last-formed dwelling-chamber was demonstrated by mercurial injection<sup>1</sup>, there is no reason to doubt that such organic connexion was maintained between the fabricator of the second chamber after it had advanced from and vacated the first or nuclear one.

The constancy of this siphuncular connexion running through all the chambers of the largest and most complex of the polythalamous shells, with the great size and singular complexity of the siphuncle in several extinct species, form the grounds on which I still hold to my original belief in the function of the siphuncle as related to a maintenance of the vitality of the shell. But this relation may be connected, also, with a greater share assigned to the siphon in the protection of the soft parts of the Cephalopod at the earlier stages of its existence.

The chief character of the tetrabranchiate chambered and siphonated shell is its affording, besides a sheath or case to the whole animal, a special protection to a part of the animal.

Such twofold office is performed by the shell in certain Gastropods, conspicuously in the genus *Calyptræa*, in which an accessory "cup," springing from the concavity of the larger "saucer," lodges part of the muscular system<sup>2</sup>.

Every chambered and siphonated shell begins in this simple fashion. The protoconch is cup-shaped or flask-shaped, and includes a similar but smaller blind beginning of the siphon.

The proportion of the inner partially protecting shell to the outer wholly encasing shell is greatest in the Silurian *Orthoceratites* ; and with the large proportional siphon are associated complexities characteristic of the genera *Ormoceras*, *Huronia*, &c.<sup>3</sup>

Modifications of the contents of such siphons in the Silurian *Vagi-*

<sup>1</sup> "The lesser aorta" sends off a small branch (14, pl. 5 & 6) "which, winding round to the ventral aspect of the ventricle (to which it is connected by a process of membrane), passes through a foramen in the septum dividing the pericardium from the cavity at the bottom of the pallial sac, is then continued through that cavity, passing between the ovary and gizzard, and lastly enters, without diminution of size, the membranous tube that traverses the partitions of the shell."—*Memoir on the Pearly Nautilus*, p. 36.

<sup>2</sup> "Its cavity is filled by what maybe termed the apex of the foot, which here loses its muscular character, and assumes a gelatinous texture."—"Anatomy of the *Calyptræidæ*," *Trans. Zool. Soc.* vol. i. p. 208, pl. 30. figs. 2, 6, f. ~~1834~~ 1835.

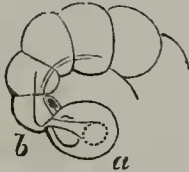
<sup>3</sup> Charles Stokes, in *Geol. Trans.* 2nd ser. vol. v. p. 706, 1837.

nati of Bohemia led the exemplary and acute observer Barrande to conceive that a larger proportion of the soft parts had been therein lodged than is the case in the slender simple siphons of other Tetrabranchiates, and in all that are of later date, when the partial office of the siphon is reduced to reception of a trace of the vascular system.

Produce both the "saucer" and "cup" of *Calypeopsis*, with the resultant "false bottoms" or septa, as in *Vermetus* (fig. 1, p. 966), and an analogue, if not parallel, of *Endoceras* would ensue.

Hyatt has noted the resemblance of the cup-like internal chambers of *Beatricea* to a line of siphonal cæca. The protoconch (primal shell, nucleus, ovisac, embryo, &c., fig. 5, a) has been determined,

Fig. 5.



*Spirula australis*.

Protoconch and protosiphon, with following chambers, magnified.

described, and figured by De Blainville (in *Spirula*<sup>1</sup>); also by Sandberger<sup>2</sup>, by Barrande<sup>3</sup>, and, with exemplary care and patience, by Alpheus Hyatt<sup>4</sup>, in various species of tetrabranchiate shells. The results by no means support any doubt as to the externality of the shells of the Ammonitidæ, or at all support the notion of their closer affinity to *Spirula* than to *Nautilus*.

The supposed well-marked distinction between the protoconch of *Ammonites* and that of *Nautilus* is mainly due, as Hyatt has shown, to its decadence in *Nautilus* after the deuteroconch (fig. 5, b), or successional shell-chamber, is formed—the primal communication with the protoconch being then indicated by a linear cicatrix on the first septum<sup>5</sup>. On this indication of the original existence and attachment of the protoconch I may remark, that when the young *Nautilus*, becoming too big for its first shell, moved on to make another, part of that "making" encroached upon the space which the young had traversed, and reduced it more or less to the shape of a chink or scar. But it must not be concluded that this chink preexisted to the progress, and that the young crept or squeezed through such chink, as when Mr. Hyatt writes of "the central scar which marks the former aperture through which the animal probably passed into the fundus of the first whorl"<sup>6</sup>. It is only under such impression that it becomes "difficult to account for the passage of the large

<sup>1</sup> *Op. cit.*

<sup>2</sup> Oberhessische Gesellschaft für Natur und Heilkunde, 1858.

<sup>3</sup> *Op. cit.*

<sup>4</sup> Fossil Cephalopods of the Museum of Comparative Zoology.—Embryology (8vo, Cambridge, Mass.), vol. iii. no. v. 1872.

<sup>5</sup> *Ibid.* p. 64.

<sup>6</sup> *Ibid.* p. 73.

body of the embryo through the narrow aperture thus made”<sup>1</sup>. The difficulty merely depended upon the “time of the making” the communicating aperture so narrow.

A true “embryology” of the Tetrabranchiates will be the welcome result and reward of the fortunate and equal student of the living *Nautilus* and *Spirula*, on the shores or in the seas they still frequent, or in the aquarium adapted to conserve and exhibit the male and female of these representatives of the almost extinct order.

I cannot conclude the present paper without expressing the pleasure with which may be confidently expected the determination of important points in the physiology of the Tetrabranchiate and Dibranchiate constructors of chambered and siphonated shells by observations made on the living specimens, under the favourable opportunities afforded by their capture to the accomplished Naturalists of H.M.S. ‘Challenger,’ whose attention had no doubt been directed to the following needful observations and experiments suggested in previous works on the subject.

“It would be advisable in the event of another fortunate capture of the *Nautilus*, to lay open the chambers under water, when the presence of gas in any of them would be ascertained; and it might be received and analyzed; the contents also of the central tube, if gaseous, would at once be detected”<sup>2</sup>.

Prof. Vrolik records similar appeals on more than one point in the structure and physiology of the constructor of the chambered shell.

“M. Owen a eu raison de dire que l’orifice *h* (pl. ii. fig. 2) est en communication avec le péricarde.”...“D’après ce que j’ai vu, le siphon s’ouvre dans la cavité abdominale, comme la pl. i. fig. 5, *c*, le démontre, et dans laquelle j’indique aussi la communication entre la cavité branchiale et le péricarde en *d*, et entre celui-ci et la cavité abdominale ou splanchnique en *e*.”...“En ouvrant la paroi postérieure du péricarde, je me suis assuré qu’au fond de celui-ci il y a une ouverture, que M. Owen a déjà reconnue, et dans laquelle pénètre une petite artère (pl. i. fig. 2, *l*). Cette ouverture est mise en rapport, près de l’ovaire et du gésier, avec la cavité abdominale.”

With regard to the course of sea-water from the branchial to the pericardial or peritoneal cavity and thence to the cavity of the siphon, or the reverse course, Vrolik appeals to the fortunate possessors of the living *Nautilus*:—“L’observation directe seule pourrait les décider”<sup>3</sup>.

And again, in regard to the circulation, especially of the venous blood:—“Serait-il possible que le sang veineux du canal intestinal fut versé dans ces interstices ou dans ces *lacunes*, pour passer plus tard, par les orifices cités, dans la veine cave; et le sang veineux des autres

<sup>1</sup> *Op. cit.* p. 74.

<sup>2</sup> Memoir on the *Nautilus pompilius*, 4to, 1832, p. 47. The same might be urged in the case of the capture of a living *Spirula*.

<sup>3</sup> “Sur quelques points de l’organisation de l’animal du Nautille Flambé.” Mémoires de la Société Linnéenne de Normandie, tom. x. (1835), p. 7, pls. i. and ii.

viscères abdominaux serait-il reçu dans des vaisseaux veineux qui se réuniraient en suite pour former les troncs que M. Owen représente planche vi. 3, 3? Je n'ai pas de réponse à donner à ces questions. L'injection du système vasculaire d'un individu à l'état frais, et l'observation d'un *Nautilus* vivant pourraient seules les éclaircir."—  
VROLIK, *op. cit.* p. 11.

EXPLANATION OF PLATE LX.

- Fig. 1. Section of *Ammonites lingulatus*, showing the opercula, *o*, displaced but retained in the dwelling-chamber.  
 2. *Ammonites subradiatus*, with the operculum, *o*, *in situ*, closing the aperture of the shell, save the space, *v*, for the passage of the respiratory currents.  
 3. Section of *Nautilus pompilius*, with diagrammatic outlines of the muscles of the shell and of the soft parts indicative of the relative position of the animal.  
 4. Section of *Spirula australis*.

In the figures 3 and 4 the parts are indicated by the same letters, as follows:—

*Shell.*

A. Dorsal wall. B. Ventral wall. a. Chambers. b. Septa. c. Hard siphon.  
 d. Soft siphon.

*Mantle.*

e. Dorsal wall. f. Ventral wall.

*Head.*

g. Tentacles or prehensile organs.

*Beak.*

h. Dorsal mandible. i. Ventral mandible. j. Funnel. k. Retractores infundibuli. l. Retractores capitis. m. Branchiæ. n. Liver.

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December 3, 1878.

Robert Hudson, Esq., F.R.S., V.P., in the Chair.

The Secretary made the following report on the additions to the Society's Menagerie during November 1878:—

The total number of registered additions to the Society's Menagerie during the month of November was 66, of which 2 were by birth, 26 by presentation, 28 by purchase, 1 received in exchange, and 9 received on deposit. The total number of departures during same period, by death and removal, was 89.

The most noticeable additions during the month were:—

1. Two examples of Horsfield's Tortoise, *Testudo horsfieldi*, from the neighbourhood of Tschina in Turkestan, presented by Dr. A. Strauch, C.M.Z.S., of the Imperial Zoological Museum of St. Petersburg, November 15th.

The species having been established by Dr. Gray upon a single young specimen<sup>1</sup>, said to have come from Afghanistan, Dr. Strauch was anxious to have examples of the Central-Asiatic species (which

<sup>1</sup> Gray, *Cat. Tort. Brit. Mus.* p. 7 (1844), and *Cat. Shield Rept. in Brit. Mus.* p. 7, tab. i. (1855).

he has excellently described in his 'Chelonologische Studien,' p. 86) compared with the original type. This, through Dr. Günther's kindness I have now been able to do; and I have no doubt of the identity of the species, in which opinion Dr. Günther fully concurs.

Besides the original type, there are two small examples of this Tortoise in the British Museum, obtained in Persia, during the Survey of the Persian Boundary Commission<sup>1</sup>; so that the species would appear to range from Afghanistan through Persia onto the shores of the Caspian and Aral seas and so into Turkestan, whence the present specimens were forwarded to the Imperial Zoological Museum of St. Petersburg by their conservator, von Russow.

*Testudo horsfieldi* in general appearance much resembles *Testudo græca*, but has only four toes on the front limbs.

2. A small blue Macaw, apparently referable to Spix's Macaw (*Ara spixi*), purchased of the Jardin d'Acclimatation of Paris, November 15, and new to the Society's collection.

This bird seems to agree in every respect with the species as described by Finsch<sup>2</sup>, except that the bare space round the eye and lores are black, and not yellow as described by Finsch and as also described and figured by Spix.

I have examined the single specimen of this species in the British Museum (obtained by purchase from a dealer in 1859), and believe it to be the same as our bird. Our specimen, of which I exhibit a figure by Mr. Smit (Plate LXI.) is generally of a bluish grey, the head of a paler light grey, a narrow naked ring round the eye; naked lores and bill black; total length about 18 inches, wing 10, tail 12. The iris is of a pale yellow.

This is the first example of this rare species I have ever seen alive. It is immediately distinguishable from *Ara hyacinthina* and *A. glauca* (of both of which we have living specimens in the collection) by its small size and small bill.

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Mr. H. Seebohm exhibited a large series of specimens of the Hooded and Carrion Crows (*Corvus cornix* and *C. corone*) and of the intermediate forms between these species, and made remarks on their geographical range and on the origin of the hybrids.

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Col. Irby, F.Z.S., exhibited and made remarks on some nests, eggs, and young of *Cypselus pallidus* taken at Gibraltar.

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Mr. Howard Saunders exhibited and made remarks on some Indian eggs, especially those of *Sterna bergii* and *Larus hemprichii*, on behalf of Capt. Butler, H.M. 83rd Regiment. These specimens had been taken on the island of Astola, on the Mekran coast.

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Dr. F. Day, F.Z.S., exhibited and made remarks on three jaws of Indian Sharks—one belonging to the genus *Galeocerdo*, and two belonging to the genus *Carcharias*,—and pointed out that one of the

<sup>1</sup> See Blanford's 'Zoology of Persia,' p. 308.

<sup>2</sup> *Sittace spixi*, Finsch, Papag. vol. i. p. 393.



Smith lith

Hanhart del

ARA SPIXI.